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(54) Electronic ballast with circuit for detecting rectification by lamp

(57) The invention relates to a protective circuit in an electronic ballast used for feeding a low-pressure electric discharge lamp, particularly a fluorescent lamp. Said ballast consists of a DC supply, a highfrequency oscillator (1, 2), and inductor (7) connected between said oscillator (1, 2) and said lamp (8). A capacitor (15, 16; 11) is connected either on the same side with or on the opposite side to said inductor (7). The protective circuit according to the invention includes a detection circuit (30-37) of lamp rectification having its operation based on the monitoring of the lamp electrode voltage. When the monitored voltage increases above or decreases below a preset level, the protective circuit halts the operation of the oscillator (1, 2).

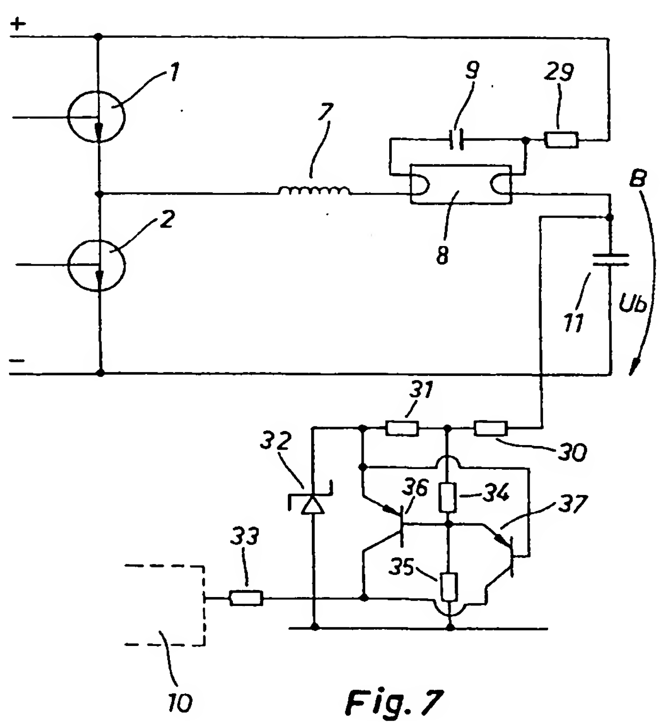

Fig. 7

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Description

The present invention relates to a protective circuit in an electronic ballast used for feeding a low-pressure electric discharge lamp, particularly a fluorescent lamp, said circuit serving to prevent a possible hazardous situation associated with the occurrence of rectification in said lamp.

The construction of electronic ballasts for low-pressure electric discharge lamps is known from the applicant's patent FI 64487 and the theoretical background of such ballasts is described in the applicant's patent FI 63314. Further related to the art is the applicant's patent FI 63146 in which is described the construction and function of an electronic ballast with a low-voltage control input capable of providing a luminous output that is proportional to the input control signal level.

The state of the art is covered by the applicant's patent FI 63148 disclosing an electronic ballast whose slightly simplified configuration is shown in Fig. 1. Over the output terminals of a DC source, such as a rectifier circuit fed by an AC supply, are connected two transistors forming a half-bridge. One terminal of the transformer primary winding is connected to the common point between the transistors and the other terminal is connected to an inductor whose other terminal is connected via a capacitor to one electrode of the lamp. The secondary windings of the transformer are connected to the bases of the transistors so as to control the transistors with opposite-phase drive voltages. Thus, when one transistor is on, the other transistor held turned off, and *vice versa*. Additionally a capacitor connected in series with the lamp electrodes acts so as to be connected in parallel with the lamp. The function of the above-described circuit is to both feed the lamp with high-frequency power inverted from the DC input voltage and start the lamp.

Such feed circuits configured about a half-bridge are conventional in the electronic ballasts of electric discharge lamps. An embodiment of such a circuit is disclosed in the applicant's patent US 4,553,070. With regard to the state of the art, reference is also made to the applicant's patent publications US 4,237,403, US 4,277,728 and US 4,370,600.

To assure reliable function and long life of electronic ballasts, it is necessary to provide them with adequate protective mechanisms against certain operating conditions deviating from those considered normal. These abnormal conditions are encountered, for instance, when the operating parameters of an electric discharge lamp - particularly those of a fluorescent lamp - deviate from their nominal values. This type of situation will normally occur with the aging of the lamp, whereby the emitter coating of the lamp cathodes is gradually eroded which causes, among other things, degradation of the lamp's starting properties. Such a phenomenon is called the deactivation of the lamp. With the aging of the lamp, also its arc voltage drop will change. Furthermore, the cathode electrodes of the lamp may break permanently due lamp aging or structural defects. One of situations further considered abnormal is an under- or overvoltage supply from the mains. If the lamp ballast is subject to an operating temperature exceeding the specified limit values, this may lead to an excessive temperature rise in the interior of the ballast, whereby the ballast may undergo a degradation of its electric components or other materials.

The above-described erosion of the lamp cathodes generally leads to a situation in which the lamp begins to rectify the current passing through the lamp. This is because the erosion of the emitter coating of the cathodes does not occur at an equal rate on both cathodes, but rather, the erosion tends to be unsymmetrical. Resultingly, since the cathodes at the two ends of the lamps start to behave differently, it is obvious that the rectification phenomenon of the lamp current emerges. This side-effect is particularly awkward in the case that the erosion of one cathode causes an unsymmetrical distribution of the voltage drop along the lamp. Then, the voltage drop is concentrated in the vicinity of one cathode only, which means a high power loss in this portion of the lamp. Such a high power loss heat the lamp bulb and, in extreme cases, causes excessive heating of the lamp holders of a luminaire. Then, it is possible that a serious hazard situation will occur, additionally involving a possible risk of fire.

Due to the above-mentioned reasons it is necessary to provide the lamp ballast with specific protective functions capable of preventing damage to the lamp ballast. For instance, the ballast can be forced into a protective status in which its oscillation is stopped. In the art, this protective status is often called a standby state. For this purpose, the ballast includes a dedicated control block serving to identify the above-described abnormal operating conditions and to control the operating status of the ballast in a suitable manner to protect its electronic components. Additionally, the control block must contain elements capable of restoring the normal operating status of the ballast when the cause of the abnormal operating conditions is removed.

In Fig. 2 is illustrated a circuit configuration for such a ballast in which the portion covered by the above-mentioned protective circuit is schematically drawn as block 10. This control block contains the required electronic circuit components required for the detection of said abnormal operating conditions through the measurement of certain electrical signals, possibly complemented with the measurement of the internal temperature of the ballast device in the manner described in patent application no. FI 965024 filed by the applicant.

It is an object of the present invention to provide a method of protecting the mains ballast of a low-pressure electric discharge lamp, particularly of a fluorescent lamp, in a situation causing current rectification in the lamp. As described above, the risk in such a situation is a destruction of the lamp and, in extreme cases, of other

luminaire components or even the entire luminaire due to overheating. As known, the detection of the lamp current rectification phenomenon is particularly difficult in ballasts designed to feed two or more lamps, because the great number of components required to implement the measurement circuits make the construction of the ballast complicated and expensive.

The goal of the invention is achieved by virtue of the specifications defined in the appended claim 1. Preferred embodiments of the invention are disclosed further in the appended dependent claims.

In the following the invention is described in greater detail by making reference to the appended drawings in which

Figure 1	shows schematically the construction of a state-of-the-art electronic ballast;
Figures 2 and 3	show alternative embodiments of the invention having the starting capacitor 11 and the measurement point arranged at different ends of the lamp 8;
Figure 4	shows a prior-art ballast in which the protective circuit according to the invention can be applied;
Figure 5	shows the voltage change at point A of Fig. 4 when the lamp enters the rectification state;
Figure 6	shows an embodiment of the protective circuit according to the invention suitable for use in the ballast illustrated in Fig. 4; and
Figure 7	shows an alternative embodiment of the protective circuit according to the invention applied to another type of ballast.

Referring to Fig. 3, therein the circuit of Fig. 2 is shown modified so that the capacitor 11 of the resonant circuit is connected to an alternative point of the circuit.

In Fig. 4 is shown a circuit configuration having the circuit of Fig. 3 complemented with a second capacitor 15 of the resonant circuit that is connected between one cathode terminal of the lamp and the positive terminal (+) of the DC power supply. Additionally, the circuit has been complemented with voltage clipper and stabilizer diodes 17 and 18, respectively, serving to keep the voltage across the capacitor 16 within desired limits. A similar circuit configuration is disclosed in the applicant's patent FI 65524. Furthermore, the circuit configuration of Fig. 4 is shown adapted for a two-lamp system, whereby the circuit includes a second lamp 13 and a resonant circuit inductor 12. While the base drive circuit of transistors 1 and 2 is not shown in Fig. 4, it can be implemented as illustrated in Fig. 3.

In a normal operating status of the ballast of Fig. 4, the voltage at point A is a symmetrical square wave having its DC level half the voltage Us of the DC circuit, typically at about 400 V in practical ballast applications. The waveform of voltage Ua at point A is plotted in Fig. 5. When one of the lamps 8 or 13 fed by the ballast begins to rectify while the other continues normal operation, the voltage at point A increases or decreases depending on the polarity of the rectified DC voltage component. This phenomenon is readily understood from Fig. 5 by examining the manner in which the relative widths of the opposite-polarity halfcycles of the square wave Ua change in various situations.

The measurement of voltage Ua at point A can be implemented, e.g., using the circuit shown in Fig. 6. The resistive voltage dividers 19/20 and 22/23 are dimensioned so that the base voltages and, consequently, also the emitter voltages of both transistors 26 and 27, respectively, will be equal when the voltage at point A is within normal limits (cf. Fig. 5a). If the voltage at point A deviates from its normal value, the transistor with the forward-biased base-emitter voltage will turn into conduction. Then, this conducting transistor will pass current into capacitor 28. This situation is detected by the protective circuit (standby circuit) as mentioned above, in the circuit description of Fig. 2. The window width of the voltage detection circuit can be set to a desired value by resistor 25. Capacitor 21 serves to filter out interfering voltage components and capacitor 24 smooths the square wave of point A into a DC voltage. Alternatively, the reference voltage may be taken from an external fixed source such as the ballast feed voltage.

In the function of the embodiment according to the invention it is essential that the rectification situation is detected and this malfunction detection signal is passed to the protective circuit block 10 of the ballast (cf. Fig. 2 and Fig. 3). Such a protective block is necessary in an electronic ballast in all cases to protect the ballast itself and the lamp(s) under different types of abnormal conditions for the reasons described above. The protective block 10 halts the operation of the oscillator circuit when the level of the monitored voltage variable, such as the DC voltage at point A of Fig. 4, exceeds a preset threshold level. The halting of the oscillator can be implemented by cutting off the base current of transistors 1 and 2, for instance. A suitable circuit configuration for this purpose is disclosed, e.g., in patent EP 0 146 683. Under the control of the protective circuit according to the invention, the ballast is steered into a protective state in which the lamps are turned off thus preventing the occurrence of a possible hazard situation.

In Fig. 7 is illustrated an application of the invention in a ballast having its resonant circuit implemented in the manner shown in Fig. 3. Therefore, this type of ballast does not have two resonant circuit capacitors as

shown in Fig. 4, but instead the resonant circuit capacitor 11 is complemented with a resistor 29 connected between one cathode of the lamp and the positive terminal (+) of the DC power supply. The voltage waveform Ub at point B is plotted in Fig. 8. This voltage is measured by means of a circuit consisting of resistors 30, 31, 33, 34 and 35, transistors 36 and 37, as well as a zener diode 32. The operating principle of the circuit is similar to that described above for the circuits of Figs. 4-6. However, a difference is therein that the reference voltage of the circuit is formed by means of components 31 and 32 from the measurement voltage itself. By a suitable design of this circuit configuration, the measurement voltage Ub having a normal voltage level of about 200 V is monitored within a preset voltage window (with limit values Uyr and Uar drawn in the diagram of Fig. 8), whereby any excursion of the measurement voltage Ub outside these limits will turn on either transistor 36 or 37, whereby a detection signal is passed to the protective block 10 via resistor 33. The advantage of this circuit is based thereon that normally the ballast circuitry already contains all the circuit components except components 34, 35, 36 and 37, whereby the extra cost due to the circuit configuration according to the invention remains extremely modest.

The circuit embodiments according to the invention are characterized in that the detection of lamp current rectification in an electronic ballast feeding a single-lamp or multilamp system is accomplished by virtue of very simple and cost-efficient circuit designs. As the protective circuit 10 is invariably included in a modern electronic ballast for the purpose of managing different types of abnormal operating situations, the elimination of the dangerous lamp rectification phenomenon is now attained in a simple, reliable and cost-efficient manner.

To a person versed in the art it is obvious that the applications of the invention are not limited by the circuit configurations illustrated in Figs. 4-6 and Fig. 7. For instance, transistors 1 and 2 can be replaced by insulated-gate field-effect transistors (MOSFET). Further, the rectification detection circuit block (cf. Fig. 6 and Fig. 7) may be implemented using an operational amplifiers. Also the function of the protective circuit 10 may be varied from that described above, for instance, by implementing the halting of the oscillator by means of alternative methods.

Claims

1. A protective circuit in an electronic ballast used for feeding a low-pressure electric discharge lamp, particularly a fluorescent lamp, said ballast consisting of a DC supply, a high-frequency oscillator such as a drive circuit comprising transistors (1, 2) configured into a half-bridge and an inductor (7), connected in series with the lamp, and a capacitor (11; 15, 16), **characterized** in that said protective circuit includes a detection circuit (19-27; 30-37) of lamp rectification connected to monitor the voltage between an electrode of the lamp (8) and said capacitor (11; 15, 16).

2. A protective circuit as defined in claim 1, **characterized** in that said detection circuit includes voltage divider circuits implemented with resistors (19, 21; 22, 23) and transistors (26, 27) deriving their control signals from said dividers.

3. A protective circuit as defined in claim 1, **characterized** in that said detection circuit includes at least one transistor (36, 37) deriving its control signal from a circuit consisting of at least one resistor (30, 31) and a zener diode (32).

4. A protective circuit as defined in any of claims 1-3, **characterized** in that said detection circuit is configured to halt the oscillation of the ballast oscillator or drive circuit (1, 2) when the mutual ratio of the voltages measured over said lamp (8) and said capacitor (11; 15, 16) exceeds preset limit values.

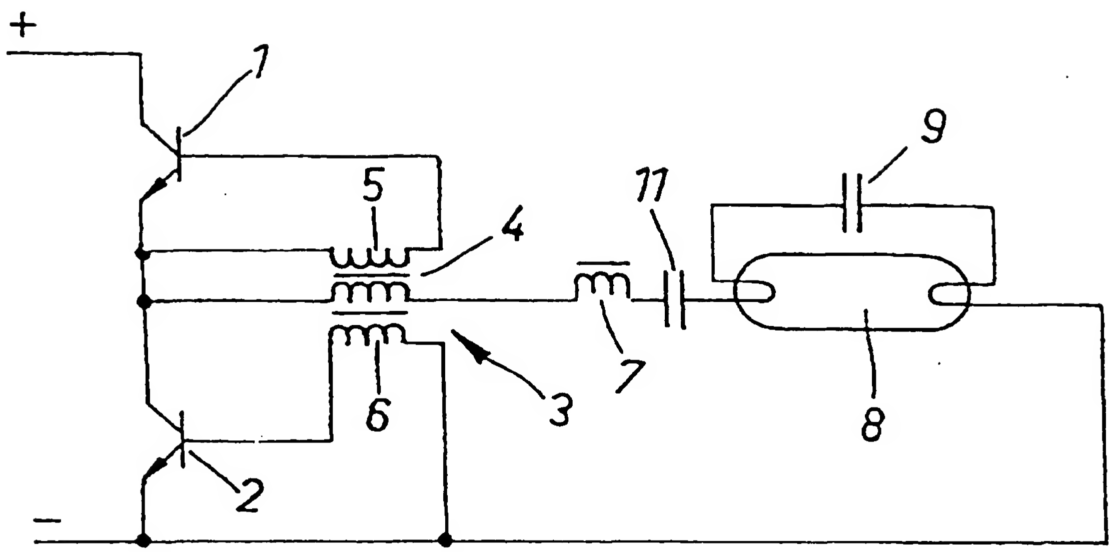

Fig. 1

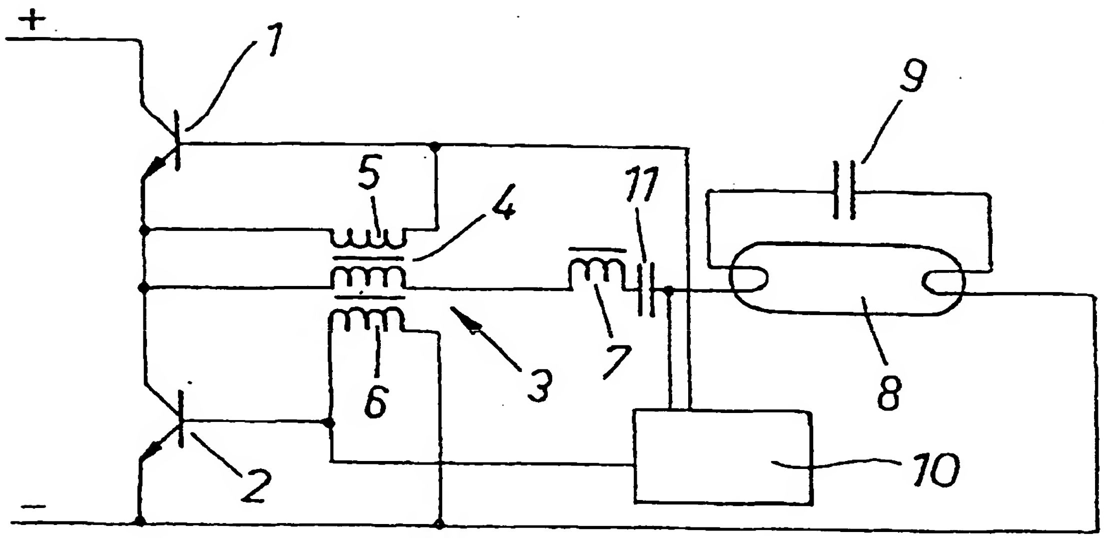

Fig. 2

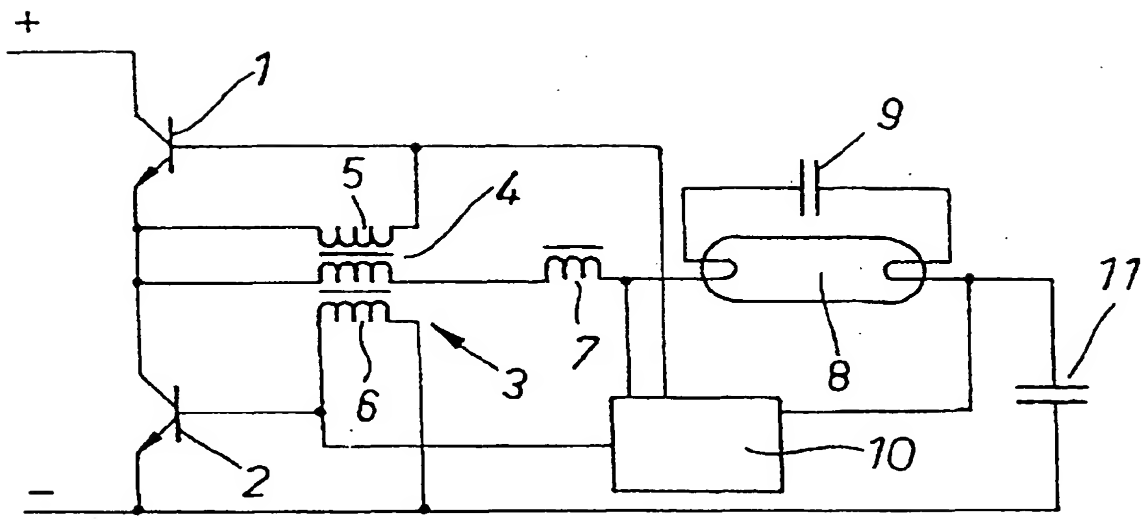

Fig. 3

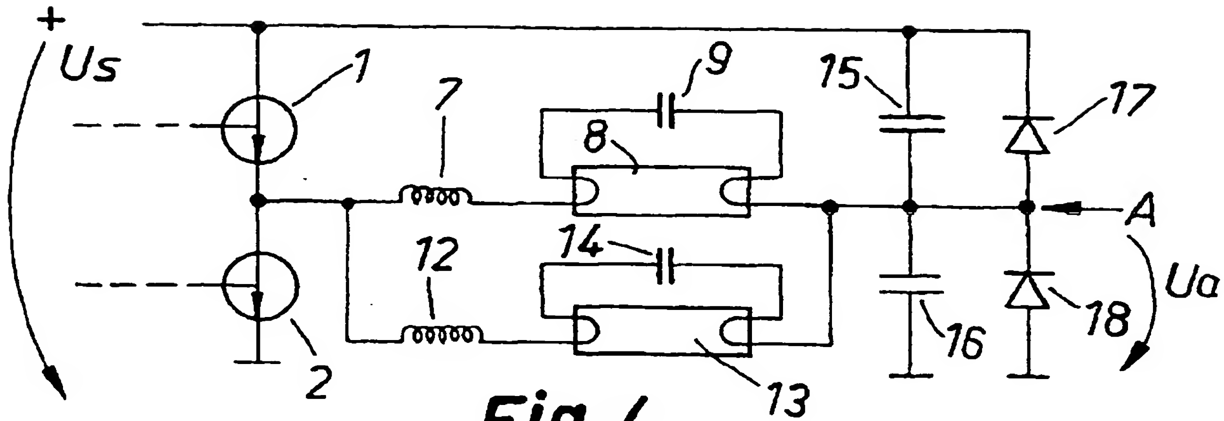

Fig. 4

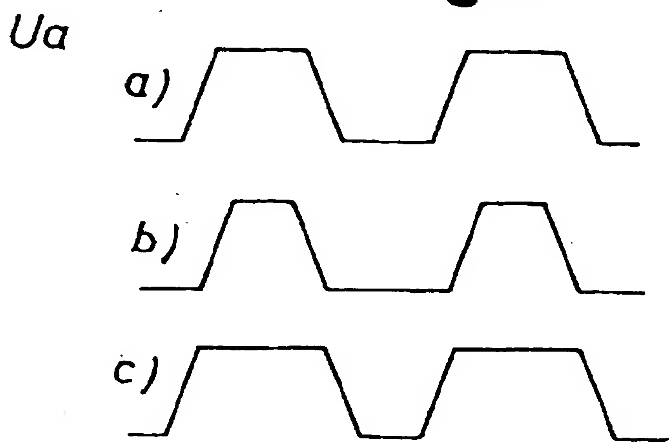

Fig. 5

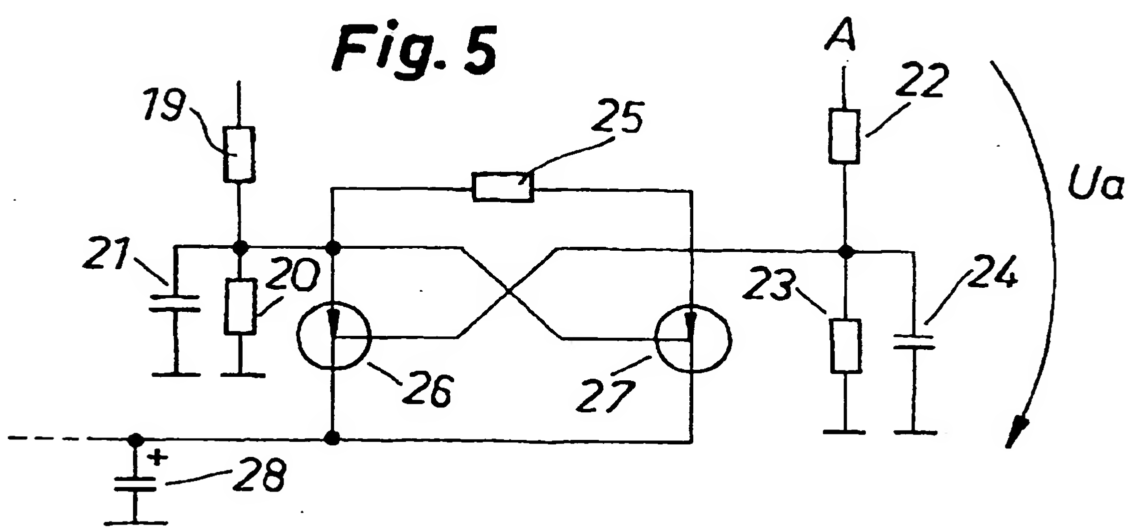

Fig. 6

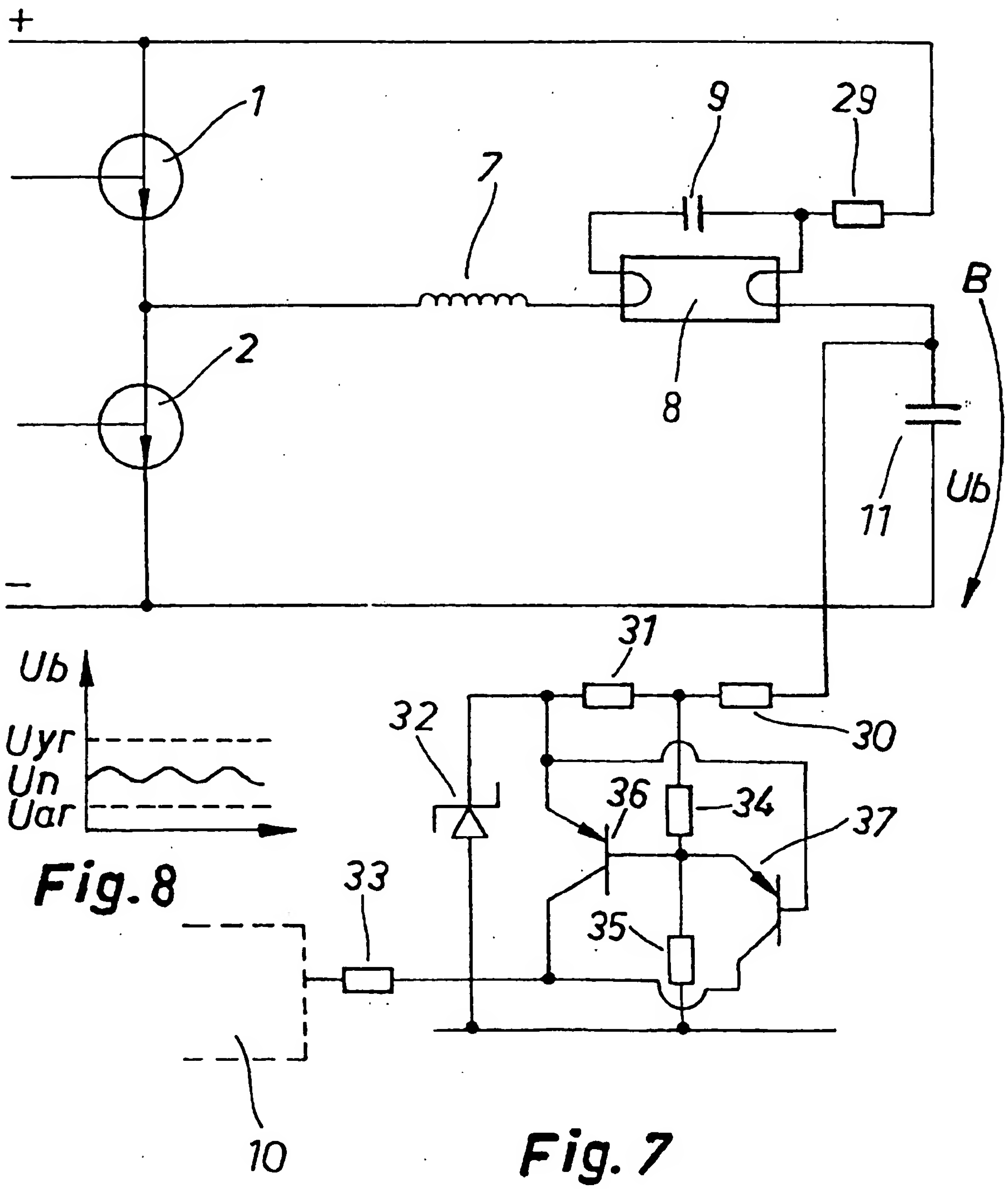

Fig.8

Fig.7